JOURNAL OF INFORMATION SCIENCE AND ENGINEERING 38, XXX-XXX (2022)
DOI: 10.6688/JISE.20220X_38(X).00XX

Quantum Logistic Improved Selective Mapping based PAPR Reduction for OFDM/OQAMs Systems*

CH RAJENDRA PRASAD+, SRINIVAS SAMALA AND SRIKANTH YALABAKA
Department of ECE
SR University
Warangal, India - 506015
E-mail: chrprasad20@gmail.com; srinu486@gmail.com; chinna7131@gmail.com

The orthogonal frequency division multiplexing with offset quadrature amplitude modulation (OFDM/OQAM) is a multicarrier modulation technique. OFDM/OQAM is a high-speed transmission technique that can effectively combat the interference between signal waveforms, and it is the core technology of the physical layer of the future generation network. Aiming at the problem of high Peak-to-Average Power Ratio (PAPR) in OFDM/OQAM system, an improved selective mapping algorithm based on quantum logistic chaotic mapping is proposed. Quantum logistic chaotic mapping is used as a random phase sequence vector to solve the fixed point and stability window problems of conventional logistic chaotic mapping. In addition, quantum logistic chaotic mapping provides a greater number of signals with random characteristics, and good correlations that are easy to generate and reproduce the signal with reduced system sideband power. The simulation results confirmed that the proposed scheme effectively minimizes the PAPR of the system, develops the number of candidate sequences, and minimizes the amount of redundant information transmission and sideband power. In comparison with traditional techniques, the proposed system is well-suitable for broad application prospects in OFDM/OQAM technology.

Keywords: OFDM/OQAM, chaotic mapping, quantum logistic improved selective mapping algorithm, PAPR, CCDF, SLM

1. INTRODUCTION

The orthogonal frequency division multiplexing with offset quadrature amplitude modulation (OFDM/OQAM) is a multicarrier modulation technique. OFDM/OQAM is a high-speed transmission technique that can effectively combat the interference between signal waveforms, and it is the core technology of the physical layer of the future generation network [1]. However, it has a high peak-to-average power ratio (PAPR) problem, which leads to non-linear distortion in the signal transmission and reduces the communication quality. So far, there are three types of PAPR reduction methods in the OFDM/OQAM system: signal predistortion, coding, and scrambling techniques. Where the signal predistortion method destroys the phase between subcarriers, and the coding method is limited by the number of subcarriers and the modulation method. In addition to that, the scrambling technique has become the main method to reduce the PAPR [2].

Received March 14, 2020; revised June 20, 2020; accepted September 28, 2020.
Communicated by Editor Jiann-Liang Chen.
+ Corresponding author. (Ch.Rajendra Prasad, Department of ECE ,SR University, Warangal, India -506015
E-mail: chrprasad20@gmail.com)

The attributes of OFDM make it attractive for wireless communication, and it is utilized for transmitting wireless data in Wi-Fi and Wi-MAX standards. OFDM is also employed in mobile communication and LTE. The primary limitation in the uplink area of LTE when utilizing OFDM is the high peak-to-average power ratio (PAPR). Various methods have been suggested to mitigate the high PAPR of OFDM. These methods are categorized according to the specific needs and availability of the parameters [3].

PAPR reduction methods in OFDM systems seek to lessen the peaks in the transmitted signal, therefore improving power efficiency and lowering the power amplifier's risk of nonlinear distortions. This is achieved using methods including Tone Reservation and Injection, Clipping, Filtering, and Selective Mapping (SLM) [4]. Clipping and Filtering reduce signal peaks but may introduce distortions that need filtering. SLM generates multiple versions of the OFDM signal and selects the one with the lowest PAPR. Tone reservation and injection use specific subcarriers to adjust the signal and reduce peaks [5,6]. Efficient power management by reducing peak power to avoid nonlinear distortions and improve the efficiency of power amplifiers. Improves signal quality and transmission efficiency by reducing the PAPR, leading to more reliable and efficient communication [7].

The SLM algorithm has a simple structure and significant effect, but it has the disadvantages of large sideband information and high computational complexity [8]. Therefore, numerous researchers have enhanced the SLM algorithm. A multi-chaos-based time-frequency domain encryption method is presented to reduce the PAPR. The logistic chaotic maps were employed to perturb the subcarriers in the time-frequency domain and securely transmit 8.9Gbit/s in 100km single-mode fiber's encrypted OFDM/OQAM signal [9].

In [10], the authors presented a hexadecimal amplitude modulation is presented for OFDM signals to minimize the PAPR. An alternative method is proposed in [11], to decrease the PAPR of OFDM/OQAM systems. In [12], a conversion vector-based low-complexity dispersive selection mapping(C-DSLM) is proposed, in the method, a series of alternative signals are generated from the conversion vectors to minimize the PAPR of the system. To address problems such as minimizing the PAPR and large sideband power, an improved selective mapping algorithm based on quantum chaotic mapping is proposed in this paper. This method combines chaotic sequences with the SLM algorithm to enable the chaotic sequences to control the generation of phase rotation factors for the OFDM/OQAM system to minimize the excessive PAPR.

In [13], the authors proposed an improved SLM algorithm, which combined the interleaved discrete cosine transformation (IDCT) with pulse-forming technology to reduce the PAPR at the transceiver. In [14], the authors proposed a method of performing cyclic shift, addition, subtraction, and sequence combination on the signal to reduce PAPR. In [15], the authors proposed µ-law compression scheme based low complexity improved SLM algorithm is employed to reduce computational complexity, and PAPR of orthogonal frequency division multiple access (OFDMA) systems. A low complexity improved SLM algorithm is employed for coherent optical OFDM/OQAM systems to reduce the PAPR by removing sideband power [16]. In [17], the authors proposed an enhanced blind differential SLM algorithm for Alamouti differential space-frequency block coding-orthogonal frequency division multiplexing (DSFBCOFDM) system, thereby reducing the PAPR of the system.

In an OFDM/OQAM system, the occurrence time of the signal peak power is uncertain, so the linear dynamic range required by the digital-to-analog converter and power amplifier is large. However, in practical applications, the signal amplitude is much smaller than this peak value. If a power amplifier is designed using this peak value as an indicator, it will greatly reduce the utilization rate and increase the system's cost. In addition, an excessively high PAPR value will cause signal distortion, destroy the orthogonality of sub-carriers, generate inter-modulation interference and out-of-band radiation, and seriously affect the system's performance. To address the above problems, an improved selective mapping algorithm based on quantum chaotic mapping is proposed in this paper. This method combines chaotic sequences with the SLM algorithm to enable the chaotic sequences to control the generation of phase rotation factors for OFDM/OQAM system to minimize the excessive PAPR

The following points outline the paper's major contributions:

- A novel quantum logistic improved selective mapping (QL-MSLM) algorithm is introduced to significantly reduce the PAPR in OFDM/OQAM systems in OFDM systems.
- Quantum logistic chaotic mapping (QLCM) is utilized to generate random phase sequence vectors (RPSV), addressing the issues related to fixed points and stability windows.
- The PAPR distribution is analyzed using a complementary cumulative distribution function (CCDF).
- The performance of the proposed QL-MSLM is compared to the conventional C-SLM method in terms of PAPR reduction efficiency with RPSVs.

The remaining paper is structured as: The Conventional SLM (C-SLM) Algorithm, QLCM and proposed QL-MSLM Algorithm are discussed in Section 2. Section 3 explains the findings and discussions. The work is concluded in Section 4.

2. MATERIALS AND METHODS

2.1 C-SLM Algorithm

The C-SLM algorithm is employed for OFDM/OQAM signals to reduce the PAPR without distortion. The specific steps of the C-SLM algorithm are as follows.

Step 1: Set the input signal of IFFT on X as:

$$X = (X_0, X_1, ..., X_{N-1}) \tag{1}$$

The transmitter generates M different RPSVs with length N and is given by:

$$P^{(m)} = (P_0^{(m)}, P_1^{(m)}, ..., P_{N-1}^{(m)}) \tag{2}$$

where, m = 1, 2, …, M, $P_i^{(m)} = e^{j\varphi_i^{(u)}}, \varphi_i^{(u)}$ is uniformly distributed in [0, 2π].

Step 2: Perform multiplication on M RPSVs on the input signal X to obtain M different output sequences of length N, as follows:

$$X^{(m)} = XP^{(m)}\left(x_{n+1} + y_{n+1} + z_{n+1}\right) = \left(X_0 P_0^{(m)}, X_1 P_1^{(m)}, ..., X_{N-1} P_{N-1}^{(m)}\right)\left(x_{n+1} + y_{n+1} + z_{n+1}\right) \tag{3}$$

Step 3: Perform IFFT operations on the *M* different output sequences $x^{(m)}$ respectively to obtain *M* output sequences in the time domain, as shown below:

$$x^{(m)} = (x_0^{(m)}, x_1^{(m)}, ..., x_{N-1}^{(m)}) \tag{4}$$

Step 4: Choose the group with the best PAPR performance among the *M* output sequences.

As the number of random phase sequences *M* increases, the number of IFFT transformations performed by the system also increases, thus, the traditional SLM algorithm becomes more complex. When there are 128 subcarriers and the number of RPSVs *M*=2,4,6,8, respectively, the PAPR performance of the C-SLM algorithm is shown in Fig 1.

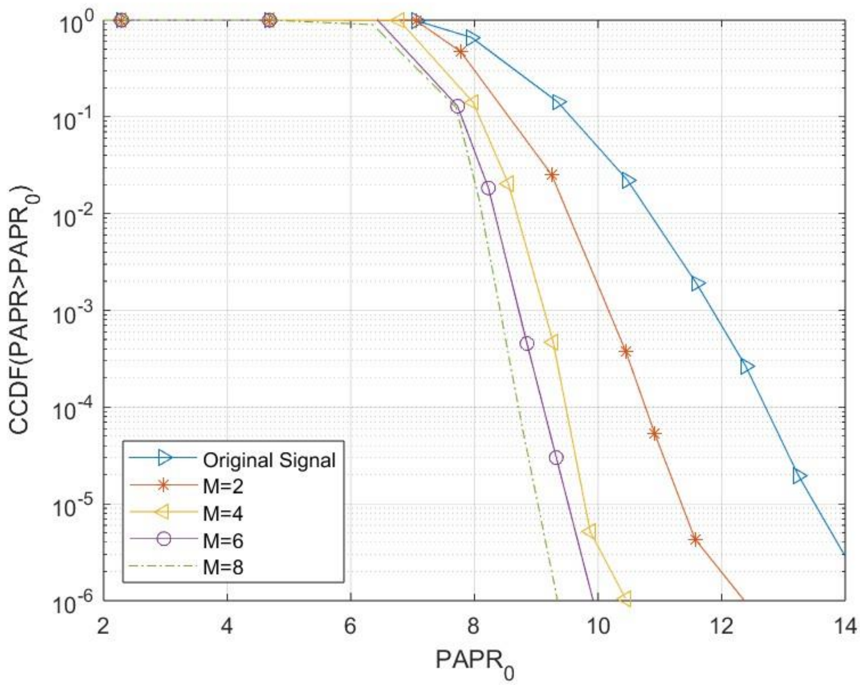

Fig. 1. PAPR performance curve of C-SLM algorithm under different RPSVs.

It can be seen from Fig. 1 that the PAPR performance of the traditional SLM algorithm is proportional to the number of RPSVs. The larger *M* is, the better the PAPR performance of the system, but the complexity of the algorithm will also increase.

2.2 The QLCM

Xu, B., et al. [18] quantified the conventional logistic chaotic map employing the reverse rotor model method to generate a QLCM. In this paper, the QLCM is digitized as an RPSV which is given in Eq. (5) and it is defined as follows:

$$\begin{cases} x_{n+1} = 1-(x_n - |x_n|^2) - \alpha y_n \\ y_{n+1} = y_n e^{-2\beta} + e^{-\beta}\alpha\left[(2-x_n-x_n^*)y_n - x_n z_n^* - x_n^* z_n\right] \\ z_{n+1} = z_n e^{-2\beta} + e^{-\beta}\alpha\left[2(1-x_n^*)z_n - 2x_n y_n - x_n\right] \end{cases} \tag{5}$$

where α is a tunable parameter, β is a dissipation parameter, x_n , y_n, z_n are system state parameters, and x_n^*, y_n^*, z_n^*, are complex conjugates of x_n, y_n, z_n. Where $x\in(0, 1)$, $y\in(0, 0.2461)$, $z\in(0, 0.2461)$, $\alpha\in(3.74, 4.0)$, $\beta\in3.5$, the system is chaotic. The parameters $(x_{n+1}, y_{n+1}, z_{n+1})$ used in Eq. (5) reduces the effect of quantum correlation.

In comparison to conventional pseudo-random sequences, the quantum chaotic sequences can generate a large number of signals that are easy to generate and reproduce, have good correlation and randomness, and overcome the defect of a large number of sharp pulses in the conventional pseudo-random code cross-correlation function. By introducing terminal perturbation, the QLCM solves the issues of fixed point and stability windows of conventional logistic chaotic maps and improves the accuracy of floating-point operations.

The C-SLM algorithm is a distortion-free peak-to-average ratio suppression algorithm. The advantage is that it does not cause signal distortion, but at the receiving end of the system, it should know the designated random phase sequence for demodulation [19, 20]. Therefore, in addition to transmitting data information, a corresponding random phase sequence needs to be transmitted, which greatly increases the sideband information transmitted, which limits its practical application. For the C-SLM algorithm, the receiver requires to transmit the designated RPSVs to correctly restore the original signal, and it needs to transmit the entire sequence, namely $P^{(m)} = (P_0^{(m)}, P_1^{(m)}, \ldots, P_{N-1}^{(m)})$ the amount of information is *N*.

To generate a pseudo-random sequence, a QLCM is employed in this paper. The sequence is generated iteratively from the primary value. Then it is only required to transmit its primary value, which minimizes the computational complexity, transmits sideband information and reduces the sideband power.

2.3 Quantum Logistic Improved Selective Mapping Algorithm

Pointing at the deficiencies of C- SLM algorithms such as large sideband power and a small number of candidate sequences, this paper proposes a quantum logistic improved selective mapping (QL-MSLM) algorithm, which uses a segmentation method to divide the original signal into real-part signals. And imaginary signals, QLCM are used instead of conventional pseudo-random sequences such as RPSVs, to perform point multiplication operations with real and imaginary signals, respectively, and then IFFT transformation is performed. Calculate PAPR and select the smallest PAPR for transmission. The specific principle is shown in Fig. 2.

The input to OFDM/OQAM data block is *s(t)*, which is a serial input and is symbol mapped. The *s(t)* is divided into 2M subchannels by serial-to-parallel converter. Then *s(t)* is decomposed into real and imaginary signals by the segmentation method and is transmitted on *M* subchannels, respectively. The QLCM is employed to produce M different

RPSVs P with length N, and $P^{(m)} = (P_0^{(m)}, P_1^{(m)}, \dots, P_{N-1}^{(m)}) \quad 0 \le m \le M-1$.

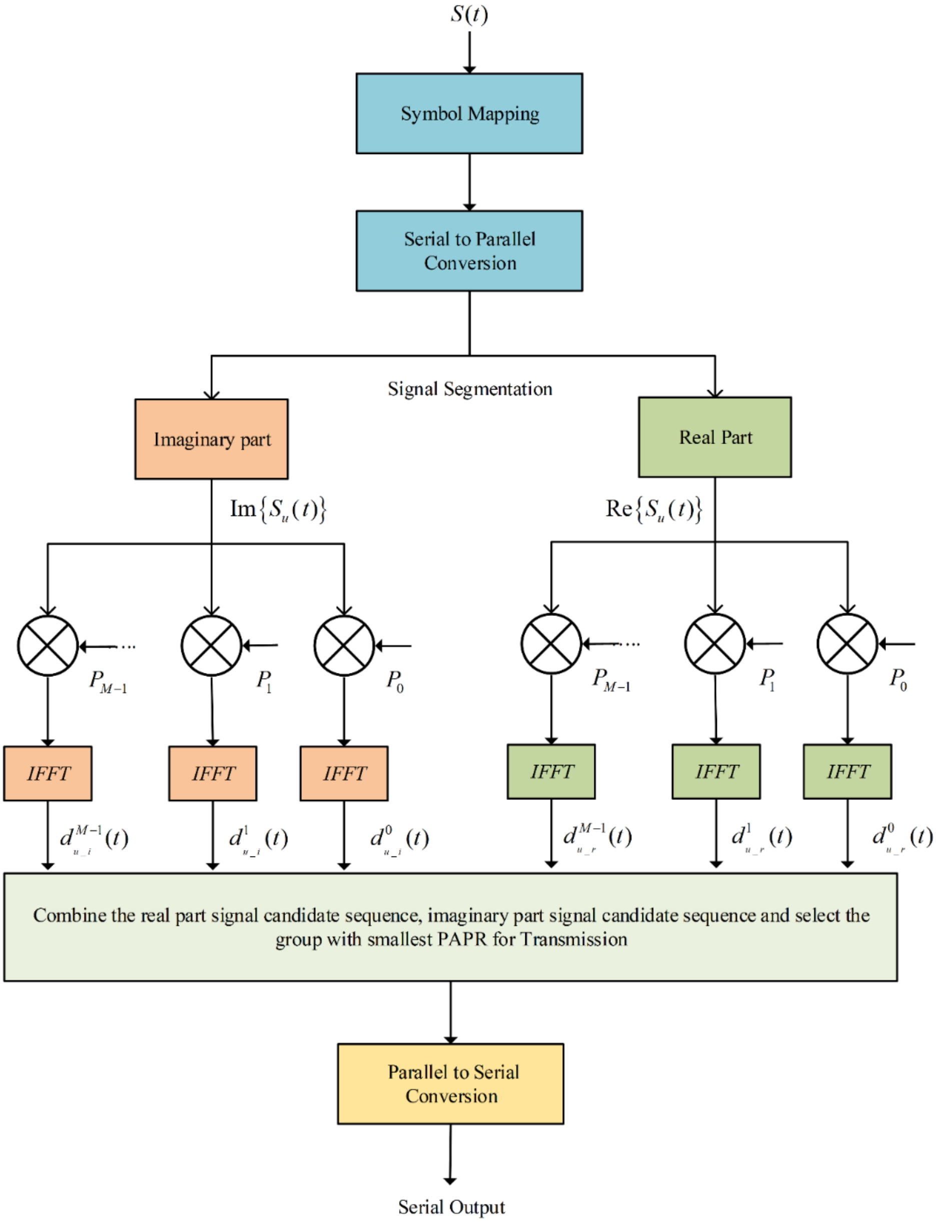

Fig. 2. Principle of the quantum logistic improved selective mapping algorithm

$S_u(t)$ is the u_{th} data block, which is decomposed as a real part $Re\{S_u(t)\}$ and imaginary part $Im\{S_u(t)\}$ and multiplied with the Pm, and then candidate transmission sequences $Re\{d_u^m(t)\}, Im\{d_u^m(t)\}$ are generated using IFFT.

$$Re\left\{d_u^m(t)\right\} = IFFT(Re\left\{s_u(t)\right\} \otimes P^m)$$

$$Re\left\{d_u^m(t)\right\} = IFFT\left(Re\left\{s_{u,0}(t)\right\} P_{m,0}, Re\left\{s_{u,1}(t)\right\} P_{m,1}, Re\left\{s_{u,N-1}(t)\right\} P_{m,N-1}\right) \tag{6}$$

$$Im\left\{d_u^m(t)\right\} = IFFT(Re\left\{s_u(t)\right\} \otimes P_m)$$

$$Im\left\{d_u^m(t)\right\} = IFFT\left(Im\left\{s_{u,0}(t)\right\} P_{m,0}, Re\left\{s_{u,1}(t)\right\} P_{m,1}, Im\left\{s_{u,N-1}(t)\right\} P_{m,N-1}\right) \tag{7}$$

where $\otimes$ is a dot multiplication operator between two vectors, m is range from 0 to M-1, IFFT is an Inverse Fast Fourier Transform, $Re\{d_u^m(t)\}$is a candidate sequence of real parts, $Im\{d_u^m(t)\}$ is a candidate sequence of imaginary parts.

The candidate sequence, $Re\{d_u^k(t)\}$, $Im\{d_u^k(t)\}$of the real part and imaginary part of the signal are linearly combined to obtain the candidate transmission sequence $d_u^{(k,q)}(t)$ is as follows:

$$\begin{aligned} d_u^{(k,q)}(t) &= \alpha_k Re\left\{d_u^k(t)\right\} + j\beta_k Im\left\{d_u^k(t)\right\} \\ &= \alpha_k IFFT\left(Re\left\{s_u(t)\right\} \otimes P_k\right) \pm j\beta_k IFFT\left(Im\left\{s_u(t)\right\} \otimes P_q\right) \end{aligned} \tag{8}$$

If $\alpha_k P_k \pm \beta_k P_k$ is a phase sequence vector, i.e. $|\alpha_k| = |\beta_k| = 1/\sqrt{2}$ and then PAPR is equal for positive polarity and negative polarity.

$$d_u^{(k,q)}(t) = \frac{1}{\sqrt{2}} IFFT\left(Re\left\{s_u(t)\right\} \otimes P_k\right) \pm j\beta_k IFFT\left(Im\left\{s_u(t)\right\} \otimes P_q\right) = \frac{1}{\sqrt{2}}\left(Re\left\{d_u^k(t)\right\} \otimes j\beta_k Im\left\{d_u^q(t)\right\}\right) \tag{9}$$

The candidate transmission sequence $d_{eu}(t)$ extended by Eq.(9) is increased from the original M to $M2$, and the specific identification is as follows:

$$d_{eu}(t) = \left\{d_u^0(t), d_u^1(t), \ldots., d_u^n(t), .., d_u^{(M^2-1)}(t)\right\} \tag{10}$$

For the u_{th} data block candidate transmission sequence, the group with the smallest PAPR, is selected as X_u, then:

$$X_u = \underset{0 \le m \le M^2-1}{argmin}\left\{PAPR\left(d_u^n(t)\right)\right\} \tag{10}$$

The output sequence is $X = \sum_{u=0}^{M-1} X_u$.

3. SIMULATION RESULTS AND DISCUSSION

A QPSK modulation scheme with a number of subcarriers are 128 is considered for matlab simulations of the proposed system

The CCDF is employed to define the system's PAPR distribution. The C-DSLM presented in [10] is used to enhance the PAPR performance of the C-SLM algorithm by rotating the phase factor according to precise selection conditions. Fig. 3 illustrates the performance comparison of the proposed QL-MSLS with the C-SLM and C-DSLM algorithms. In the numerical simulation of this paper, the original signal PAPR is considered as a variable with a value of 1×128.

In the C-SLM scheme, the original signal of 1×128 is used as input data, the M group of points is multiplied by the RPSVs, and the IFFT calculation is performed to obtain the PAPR value. The variable SLM is the minimum PAPR value in the M group of candidate sequences. The C-SLM algorithm employing RPSVs needs the transmission of RPSVs information for each subchannel. Therefore, the amount of sideband information to be transmitted is very large, which not only minimizes the efficiency and it also increases the complexity of the system.

QL-MSLM algorithm has presented in this paper, the original signal of 1×128 is used as input data, the *M* group is copied, the real part and imaginary part of the data are divided, and the quantum logistic mapping generates *M* groups of rand RPSVs of phase sequence vectors. Partial signals are multiplied by RPSVs, respectively, and then after calculating IFFT, the real data and imaginary data are linearly combined. The algorithm expands the candidate sequence into the *M2* group, and the variable LSLM is the minimum PAPR value in the *M2* group candidate sequence.

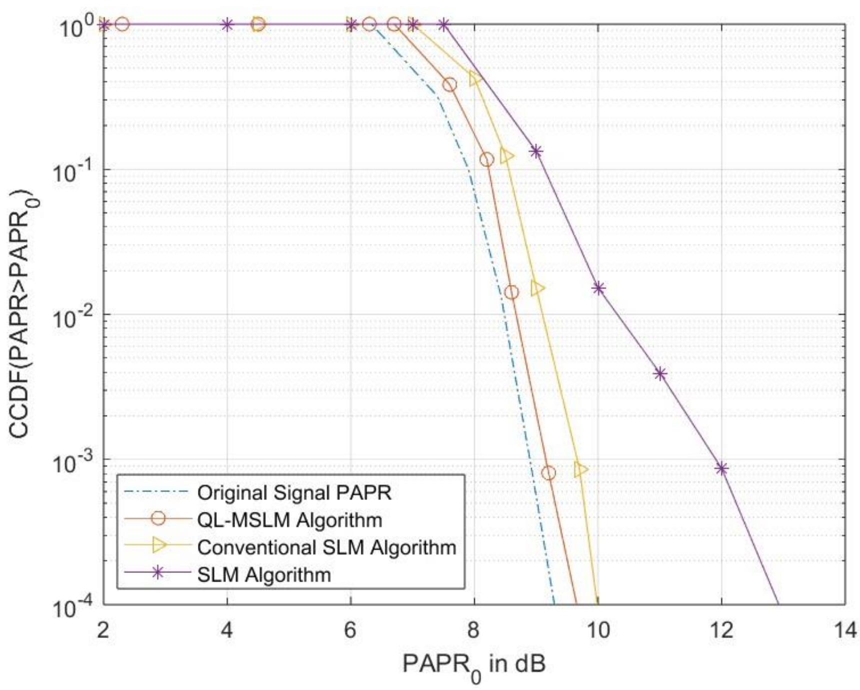

Fig. 3. PAPR performance comparison of 3 algorithms.

From Fig. 3, compared with the C-SLM algorithm and C-DSLM algorithm, the QL-MSLM algorithm proposed in this paper reduces the PAPR of the system more effectively. In this paper, the algorithm uses the segmentation method and linear combination transform to expand the number of candidate sequences, reduce the calculation amount of the algorithm, and transmit the data more efficiently. For the C-SLM algorithm, to correctly restore the original signal at the receiver, the selected RPSV needs to be transmitted, and the entire sequence needs to be transmitted, which greatly increases the sideband information and increases the sideband power.

The PAPR performance comparison of C-SLM and QL-MSLM algorithms for *N*=128 and *N*=256 is illustrated in Fig. 4. As the N value decreased, the PAPR performance of the C-SLM and QL-MSLM algorithms also reduced. In addition, sideband power is also reduced as the N value is reduced. So, PAPR performance also depends on the N value, and as the value is reduced the PAPR will be reduced for both C-SLM and QL-MSLM algorithms.

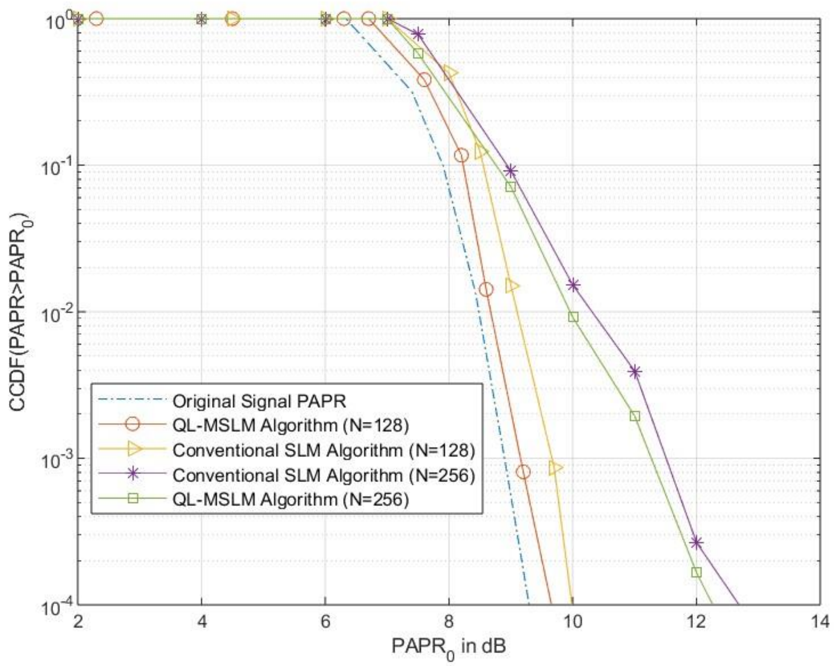

Fig. 4. PAPR performance comparison of C-SLM and QL-MSLM algorithms for N=128 and N=256

The PAPR performance curve of C-SLM and QL-MSLM algorithms for *M*=2 and *M*=8 is illustrated in Fig.5. In both algorithms, the PAPR performance is improved as *M* is increased. The QL-MSLM algorithm PAPR performance is improved more as compared with the C-SLM algorithm. However, as the number of random phase sequences M increases, the number of IFFT trans-formations performed by the system also increases, which interns increase the complexity of the overall system. So, this factor is the major restriction of the system's performance.

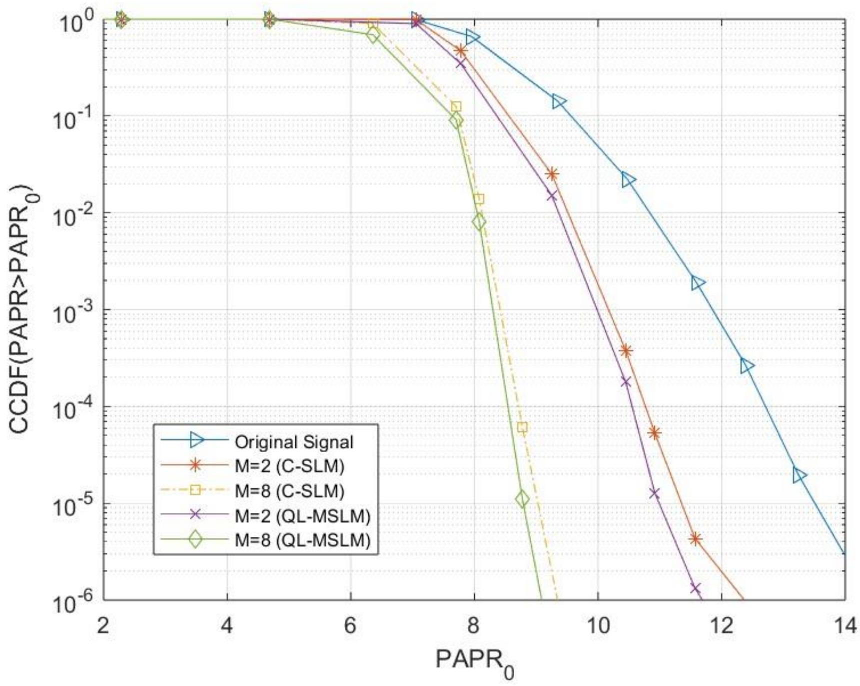

Fig. 5. PAPR performance curve of C-SLM and QL-MSLM algorithms for M=2 and M=8

The QL-MSLM algorithm proposed in this paper only needs to transmit the initial value of the quantum chaotic map to represent a set of RPSVs. The QL-MSLM algorithm proposed in this paper only needs to transmit the initial value of the quantum chaotic map to represent a set of RPSVs. The sideband power spectrum simulated by Matlab is shown in Fig. 6.

Quantum chaotic sequences do not need to store the value of each sequence point, which effectively reduces the transmission of redundant information. The proposed algorithm only needs to transmit an initial value when transmitting sideband information and does not need to transmit the phase information of each subchannel. As can be seen from Fig. 6, compared with the C-SLM algorithm, the QL-MSLM algorithm greatly reduces the amount of sideband information in transmission, reduces the sideband power, and improves the system efficiency.

This proposed PAPR reduction algorithm can lead to more reliable and efficient communication networks suitable for bandwidth-intensive applications like multimedia, and modern communication systems, including the Internet of Things.

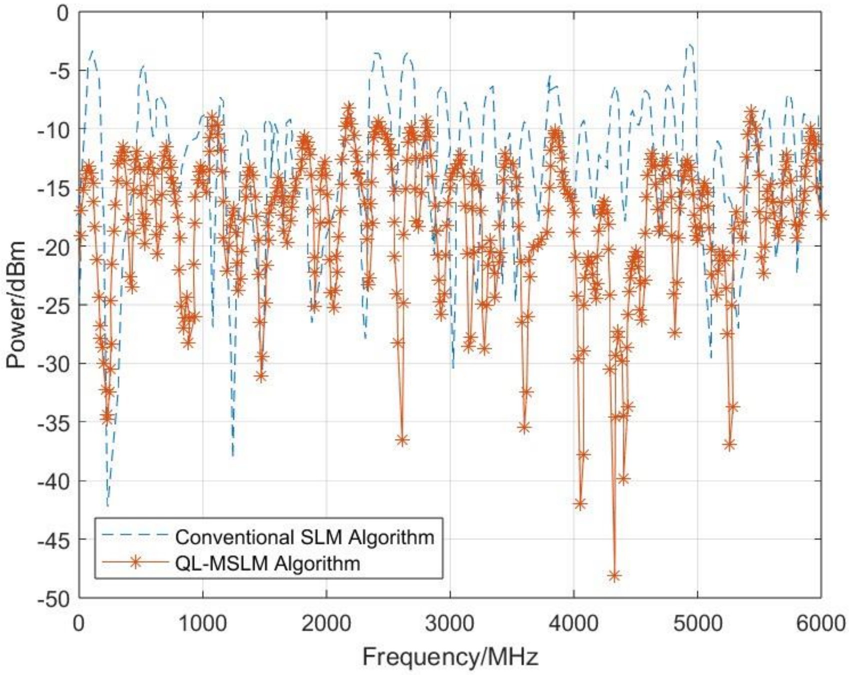

Fig. 6. Sideband Power Spectrum.

4. CONCLUSIONS

In view of C-SLM algorithm shortcomings, such as high sideband power and a low number of candidate sequences. In this paper, the proposed QLM-SLM algorithm improves the performance of the OFDM/OQAM system. The use of QLM solves the problem of fixed points and stable windows of conventional logistic chaotic maps and provides a large number of good correlation and random characteristics that are easy to generate and reproduce the signal with reduced system sideband power. Matlab simulations show that the proposed algorithm in this paper effectively reduces the PAPR computational complexity, can more efficiently carry out data transmission, and effectively reduces the transmission of redundant information. It reduces the amount of sideband information, and sideband power, and improves the system transmission.

REFERENCES

1. D. Chen, Y. and Tian, D. Qu, “OQAM-OFDM for wireless communications in future Internet of Things: A survey on key technologies and challenges,” IEEE Internet Things J., vol. 5, no. 5, pp. 3788–3809, Oct. 2018.

2. Xiao, Yaoqiang, et al. “Time-frequency domain encryption with SLM scheme for physical-layer security in an OFDM-PON system.” IEEE/OSA Journal of Optical Communications and Networking 10.1 (2018): 46-51.
3. Singhal, S., Sharma, D.K. “A Review and Comparative Analysis of PAPR Reduction Techniques of OFDM System”. Wireless Personal Communications 135 (2024): 777–803.
4. H. Xiao et al., "A Transcoding-Enabled 360° VR Video Caching and Delivery Framework for Edge-Enhanced Next-Generation Wireless Networks," in IEEE Journal on Selected Areas in Communications, 40. 5 (2022):1615-1631
5. H. Xiao et al., "Transcoding-Enabled Cloud–Edge–Terminal Collaborative Video Caching in Heterogeneous IoT Networks: An Online Learning Approach with Time-Varying Information," in IEEE Internet of Things Journal, 11. 1 (2024) : 296-310.
6. H. Xiao et al., "Task-Driven Cooperative Internet of the Robotic Things Crowdsourcing: From the Perspective of Hierarchical Game-Theoretic," in IEEE Internet of Things Journal, Early Access, 2024.
7. H. Xiao et al., "Edge Intelligence: A Computational Task Offloading Scheme for Dependent IoT Application," in IEEE Transactions on Wireless Communications, 21. 9 (20220: 7222-7237.
8. Wang, Han, et al. "Low-complexity MIMO-FBMC sparse channel parameter estimation for industrial big data communications." IEEE Transactions on Industrial Informatics 17.5 (2020): 3422-3430.
9. Cheng, Xing, et al. A novel conversion vector-based low-complexity SLM scheme for PAPR reduction in FBMC/OQAM systems. IEEE Transactions on Broadcasting 66.3 (2020): 656-666.
10. Wang, Zhiyi, et al. "Probabilistic shaping-based constellation encryption for physical layer security in OFDM RoF system." Optics Express 29.12 (2021): 17890-17901.
11. Cui, Mengwei, et al. "Multilayer dynamic encryption for security OFDM-PON using DNA-reconstructed chaotic sequences under cryptanalysis." IEEE Access 9 (2021): 18052-18060.
12. Shi, Jin, et al. "Experimental demonstration of blind equalization for OFDM/OQAM-VLC system." Optical Engineering 58.6 (2019): 066106.
13. Jeon, Hyun-Bae, Jong-Seon No, and Dong-Joon Shin. “A low complexity SLM scheme using additive mapping sequences for PAPR reduction of OFDM signals.” IEEE Transactions on Broadcasting 57.4 (2011): 866-875.
14. Wang, Chin-Liang, and Yuan Ouyang. “Low-complexity selected mapping schemes for peak-to-average power ratio reduction in OFDM systems.” IEEE Transactions on signal processing 53.12 (2005): 4652-4660.
15. Wang, C-L., and S-J. Ku. “Novel conversion matrices for simplifying the IFFT computation of an SLM-based PAPR reduction scheme for OFDM systems.” IEEE Transactions on Communications 57.7 (2009): 1903-1907.
16. Tas¸pınar, Necmi, and Mahmut Yıldırım. “A novel parallel artificial bee colony algorithm and its PAPR reduction performance using SLM scheme in OFDM and MIMO-OFDM systems.” IEEE Communications Letters 19.10 (2015): 1830-1833.
17. Katam, Seshanna, and P. Muthuchidambaranathan. “Low complexity SLM-PTS method for reduction of PAPR in OFDM systems.” 2014 3rd International Conference on Eco-friendly Computing and Communication Systems. IEEE, 2014.

18. Xu, B., Ye, X., Wang, G., Huang, Z., & Zhang, C. (2023). A Fractional-Order Improved Quantum Logistic Map: Chaos, 0-1 Testing, Complexity, and Control. Axioms, 12(1), 94.
19. Singh, Amritpal, and Harjit Singh. “Peak to average power ratio reduction in OFDM system using hybrid technique.” Optik 127.6 (2016): 3368-3371.
20. Anoh, Kelvin, et al. “A new approach to iterative clipping and filtering PAPR reduction scheme for OFDM systems.” IEEE Access

D**r. Ch. Rajendra Prasad** presently working as an Associate Professor at the Department of Electronics and Communication Engineering, S R University, Warangal, Telangana, India. He is awarded Ph.D. from Koneru Lakshmaiah Education Foundation, Guntur, Andhra Pradesh, India. He has 17 years of experience in teaching and research. He published 61 international journals and attended the 16 International Conferences and he had 15 patent publications. He is completed DST project titled “Development of Adhesive Tactile Walking Surface Indicator for Elderly and Visually Impaired People” as a co-investigator. He has ISTE and IETE Life Member ships. His areas of interests are Wireless Sensor Networks, IoT and Machine Learning.

Srinivas Samala, Assistant. Professor, Department of Electronics and Communication Engineering, S R University, Warangal, Telangana, India. He received M. Tech, degree from the JNTU Hyderabad, India. He is currently pursuing the Ph.D. degree with the School of Electronics Engineering, KIIT deemed to be University, Bhubaneswar, India. He published 14 international journals and attended the 5 International Conferences and he had 1 patent publication. His research interests include cognitive radio and networks, spectral estimation, signal processing. He has ISTE Life Member ship.

Srikanth Yalabaka, Assistant. Professor, Department of Electronics and Communication Engineering, S R University, Warangal, Telangana, India. He received M. Tech, degree from the JNTU Hyderabad, India. He is currently pursuing the Ph.D. degree with NIT Warangal, India. He published 12 international journals and attended the 2 International Conferences and he had 2 patent publications. His research interests include Embedded systems, IoT and Wireless Communication.